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PROPHYLAXIS OF LAMB DYSENTERY.

By T. Dalling, J. H. Mason, and W. S. Gordon,
Wellcome Physiological Research Laboratories, Beckenham, Kent.

The Use of Vaccine on Ewes.

The results of the vaccination of ewes with the object of protecting their offspring against Lamb Dysentery were recorded in 1926 (1). During the past lambing season we carried out further observations in Scotland, Northumberland, and Wales. In the 1926 experiments inoculating ewes in autumn and again in spring gave the best results, and this method of inoculation was used in all the 1927 experiments. The vaccine used in most cases was, as already recorded, a neutralised toxin-antitoxin made from the special type of a *B. welchii*-like organism isolated from tissues of affected lambs, and a killed suspension of many strains of *B. coli* also isolated from lambs sick of the disease. Inoculations were carried out in September or October and again in March or April. In the 1926 season injections were made subcutaneously in the thigh. Because of the degree of lameness produced in pregnant ewes by this method, we adopted a new method of inoculation for the past season's work. The under surface of the tail was chosen as a suitable site, and, with careful manipulation, vaccine can be injected there in the desired amount without causing any inconvenience to the sheep. At first it was thought advisable to " turn up " the sheep, but latterly we have been able to carry out inoculations into the tail with the ewes held in the normal standing position. No general systemic disturbance was noted after the autumn inoculations ; and in the spring, on the majority of farms, the same held good. In Northumberland, however, of 14,420 ewes inoculated, 23 died within 48 hours after the operation. We are still at a loss to account for these deaths among ewes. There is apparently no local infection ; the site of inoculation shows no lesions, and the administration of a homologous serum to ewes showing the first signs of illness after inoculation is without effect. (Vaccine from bottles actually used for inoculation has proved sterile on laboratory tests). We are of opinion that the handling of pregnant ewes must be carried out with the utmost care, as several farmers have volunteered the information that the mere " gathering " of flocks of pregnant ewes and their herding in sheep pens is often attended by several deaths.

Results in Scotland.

In the South of Scotland, over an area of about 1,200 sq. miles, 4,015 ewes were inoculated, while 2,137 were left untreated as controls. The inoculated and control ewes were from the same " cuts " of sheep on the same " hirsels " of the same farms, and no selection was made in any way. During the whole of the lambing period one of us (W.S.G.), visited the various farms at regular intervals, and carried out post-mortem work on almost every lamb dead from any cause whatever, including those " still born."

In Table I we have shown the results of this experiment. Of 4,140 lambs born from inoculated ewes, 36 or 0·87 per cent. died of lamb dysentery, while of 2,213 lambs from uninoculated control ewes, 178 or 8·04 per cent. died of lamb dysentery.

On some hirsels on farms in Scotland no control ewes were kept, the entire ewe stock being inoculated. Hirsels on which the death rate from lamb dysentery for at least the past two years was high were selected for this work. Table II shows the result of this experiment ; of 1,029 lambs born from inoculated mothers, 8 or 0·77 per cent. died of lamb dysentery.

TABLE I.

Double Inoculation (Autumn and Spring).

Controls kept in same lots of sheep. Every dead lamb submitted to post-mortem examination by us.

Farm.	*Ewes Inoc.*	*Breed.*	*Lambs born.*	*Lambs died L.D.*	%	*Con-trol Ewes.*	*Lambs born.*	*Lambs died L.D.*	%
A.2	113	Ch.	113	1	0·88	36	36	11	30·55
B.1 2	96 238	Ch. Ch.	96 238	1 3	1·04 1·25	352 84	352 84	25 1	7·1 1·19
C.1	274	Ch.	274	7	2·55	90	90	9	10
D.	140	Ch.	140	2	1·42	132	132	19	14·39
E.2	89	B.F.	89	3	3·36	102	102	16	15·67
F.	192	Ch.	192	3	1·56	64	64	10	15·62
G.	327	Ch.	372	3	0·8	356	356	19	5·33
H.1	459 259 360 309	Ch. Ch. Ch. Ch.	459 259 360 309	— — 2 2	0 0 0·55 0·64	150 70 120 104	150 70 120 104	7 1 8 3	4·66 1·42 6·66 2·88
I.	183	Ch.	192	1	0·52	72	77	4	5·19
J. 1 2	80 139	Ch. Ch.	82 149	1 1	1·21 0·67	172 73	177 78	15 10	8·47 12·82
K.1 2	360 318	Ch. Ch.	360 318	2 3	0·55 0·94	50 80	50 80	5 3	10 3·75
L.	79	B.F.	79	1	1·26	30	30	5	16·66
M.	50	Welsh	59	—	0	50	61	7	11·47
	4065		4140	36	0·87	2187	2213	178	8·04

It is interesting to note that on nearly all farms the death rate among lambs from inoculated ewes took place during the later stages of the lambing period, while among lambs from control ewes the death rate was more or less evenly distributed through the whole period after the first week had passed and occurred in proportion to the number of lambs born. We have carried out an extensive study on the degree of immunity produced in the lambs born from inoculated

TABLE II.

DOUBLE INOCULATION (AUTUMN AND SPRING).
No controls kept. Every dead lamb submitted to post-mortem examination by us.

Farm.	*Ewes Inoc.*	*Breed.*	*Lambs born.*	*Lambs died L.D.*	%
A.1	95	Ch.	94	2	2·12
C.2	252	Ch.	288	0	0
3	233	Ch.	257	1	0·38
E.1	364	B.F.	390	5	1·28
	944		1029	8	0·77

ewes and have found that the antitoxic content of the blood of newly born lambs is of the same titre as that of the inoculated mother when tested on the day of the lamb's birth, and that the degree of immunity in the mother falls off rapidly several weeks after the second injection. This work is fully recorded in a paper about to be published. We believe from this and other observations that a considerable percentage of lambs born from inoculated ewes are immune to infection with the type of *B. welchii* isolated from cases of lamb dysentery and that the immunity lasts for at least one week.

TABLE III.

DOUBLE INOCULATION. (AUTUMN AND SPRING).
No Controls kept. Figures supplied by farmers. No post-mortem work done.

Farm.	*Lambs born.*	*Lambs died L.D.*	%
A.	361	22	6·09
B.	983	50	5·08
C.	405	13	4·21
D.	226	5	2·22
E.	709	54	7·61
F.	1336	86	6·43
G.	400	34	8·5
H.	1392	92	6·61
I.	150	0	0·0
J.	218	10	4·58
K.	230	3	1·31
L.	338	4	1·18
M.	297	8	2·67
N.	160	8	5·00
O.	400	19	4·75
P.	829	27	3·25
Q.	161	12	7·45
R.	625	9	1·44
S.	1152	45	3·91
T.	900	17	1·88
U.	1034	25	2·41
V.	326	11	3·46
W.	507	13	2·56
X.	419	43	10·26
Y.	170	3	1·77
Z.	732	15	2·05
AA.	400	20	5·00
BB.	375	2	0·53
CC.	300	0	0·0
DD.	25	0	0·0
	15560	650	4·17

Results in Northumberland.

As most of our experimental work in the 1926 season was carried out in Northumberland and the farmers were not inclined to experiment further, but desired the whole of their ewe breeding stock inoculated, we decided to meet the wishes of the farmers and leave no controls. Therefore the results recorded in Table III cannot be compared with those in which controls were kept, as in those of last year in the same districts or in Scotland during the past season. Post-mortem examinations were made only in exceptional cases, and the figures recorded in the Table were supplied to us at the end of the lambing season by the farmers themselves. It may be noted here that on a few farms it was arranged to keep a small percentage of controls, but on investigation it was soon evident that the controls, as selected by the farmers, had in most cases been inoculated in 1926 and in some cases in 1924 and 1925, or were not actually grazing on the same land as those inoculated ; we therefore decided to reject them entirely. Table III shows that of 15,560 lambs born from inoculated ewes, 650 or 4·17 per cent. died of lamb dysentery.

The mortality of 4·17 per cent. in the Northumberland area against 2·34 per cent. in the same district in 1926 and 0·87 per cent. in carefully controlled experiments in Scotland, has made us wonder if the vaccine used in the two districts had the same antigenic value. In both areas the same batch of vaccine, C, was used for the autumn inoculations. For the spring work, however, the autumn batch, C, stored in Northumberland, was used in Northumberland, while the new batch, DD, was made for the experimental ewes in Scotland. On guinea-pig test, both batches gave approximately the same degree of protection when tested soon after being made. Since lambing finished experiments have been carried out to see if the two batches had retained their original antigenic value. Of 24 guinea-pigs receiving two injections of Batch C, nine withstood a lethal dose of toxin when tested a fortnight after the second injection, while of twelve guinea-pigs injected with Batch DD and similarly tested, ten were immune. From this experiment it is probable that one explanation of the difference in results in Scotland and Northumberland is the " falling off " of the antigenic value of Batch C, kept for over six months before being used for the second or spring inoculation. Experiments are now in progress to test the keeping properties of lamb dysentery vaccines from an antigenic standpoint.

W. Lyle Stewart, M.R.C.V.S., Veterinary Advisor, Armstrong College, Newcastle, kindly offered to carry out a controlled experiment in Northumberland. The method of inoculating was carried out as already described. The figures in Table IV show that in controlled

TABLE IV.
DOUBLE INOCULATION.

Ewes Inoc.	*Lambs born.*	*Lambs died L.D.*	%	*Control Ewes.*	*Lambs born.*	*Lambs died L.D.*	%
430	531	5	0·94	536	674	19	2·81

experiments vaccination of the ewes was followed by a lower death rate among their lambs than among those born from uninoculated ewes, though the incidence of the disease was low.

Results in Wales.

On two farms only were inoculations carried out. On Farm A 79 ewes produced 77 lambs of which one died from lamb dysentery, while from 80 lambs born from control ewes twelve died from lamb dysentery. On Farm B 256 ewes were inoculated and 274 were left as controls. We do not know definitely the number of lambs which died of lamb dysentery. While on Farm A the owner made every effort to carry out our instructions and keep records, the owner of Farm B. could tell us nothing of what had happened except that he thought about 80 lambs, of which one-third were from inoculated ewes, had died of lamb dysentery.

The Use of Serum on Young Lambs.

Serum made from the lamb dysentery type of *B. welchii* without the addition of that made from *B. coli* has been largely used during the past season. Lambs were injected with 5 c.c. as soon after birth as possible, in most cases within twelve hours. Farms and shepherds made the inoculations and every inoculated lamb was specially marked. Inoculations were made subcutaneously in the thigh or neck.

A.—*Farms where controls were kept.*

In all districts (Scotland, Northumberland, Wales, and Hampshire) experiments were carried out in which approximately every second lamb born was inoculated, the other lamb receiving no treatment. Post-mortem examinations were made on nearly every lamb dead, no matter what the cause. No ill-effects are reported from the use of serum. Table V shows that of 112 inoculated lambs five died of lamb dysentery, while of 1241 control lambs 213, or 17·16 per cent., died.

TABLE V.
SERUM.
Lambs injected within 12 hours of birth. Every second lamb born injected.

Farm.	*Lambs Inoc.*	*Breed.*	*Lambs died L.D.*	%	*Control lambs.*	*Lambs died L.D.*	%
A.	126	Ch.	0	0	49	7	14·28
B.	65	Ch.	0	0	40	8	20
C.	80	Ch.	0	0	132	19	14·39
D.	70	Ch.	0	0	71	10	14·08
E.	28	Welsh	0	0	27	5	18·51
F.	13	Welsh	0	0	21	12	57·14
G.	180	B.F.	2	1·11	200	40	20·00
H.	80	Mule	0	0	100	15	15·00
I.	46	H.B.	0	0	44	6	13·63
J.	28	Welsh	0	0	33	5	18·18
K.	13	Welsh	1	7·7	8	7	87·5
L.	200	B.F.	2	0·1	200	38	19·0
M.	70	Ch.	0	0	71	10	14·08
N.	62	Ch.	0	0	126	7	5·55
O.	61	Ch.	0	0	119	24	20·16
	1122		5	0,44	1241	213	17·16

B.—*Farms on which no controls were kept.*

Such farms were mostly in Northumberland and serum was used usually from the beginning of lambing. Post-mortem work was not carried out, no controls were kept, and the figures were supplied by the farmers at the end of the lambing season. On all farms the death rate had been heavy for the past two or more years. The results are tabulated in Table VI, and show that of 1,877 lambs so treated, two died of lamb dysentery. The serum used on these farms was 50 per cent. lamb dysentery *B. welchii* antitoxin and 50 per cent. *B. coli* antiserum.

TABLE VI.

SERUM.

Uncontrolled. All lambs on infected farms were injected with serum soon after birth.

Farm.	*Lambs injected.*	*Lambs died.*
A.	820	2
B.	650	0
C.	210	0
D.	70	0
E.	52	0
F.	75	0
	1877	2

Hare and Glynn (2) suggest that our serum results in 1926 may be due in part to the non-specific action of horse serum. In 1927 we attempted to carry out an experiment in which lambs on an infected farm were to be injected with normal horse serum. Unfortunately, owing to the low incidence of the disease on this selected farm, we are unable to draw any conclusions. We know, however, from work some years ago that a low titre serum (made from organisms isolated from lamb dysentery subjects) proved useless in preventing the disease.

Experiments with L.D. B. welchii T.A.M. alone.

We carried out a number of experiments in which toxin-antitoxin made from the lamb dysentery type of *B. welchii* alone constituted the vaccine. The results of injecting serum made from the L.D. type of *B. welchii* into young lambs suggests that *B. coli* has little pathogenic significance on lamb dysentery, and the results recorded in Table VII would seem to strengthen this view. Two types of experiment were undertaken : (*a*) inoculation of ewes once in autumn and once in spring, and (*b*) inoculation of pregnant ewes twice in the spring.

Of 466 lambs born of ewes inoculated once in autumn and once in spring, five or 1·08 per cent. died of lamb dysentery, while of 105 lambs born from control ewes on the same hirsels, 14 or 13·33 per cent. died. Of 1,934 lambs born of ewes inoculated twice in the spring, 42 or 2·17 per cent. died of lamb dysentery, while of 187 lambs born of inoculated ewes on the same farms, ten or 5·34 per cent. died.

Summary and Conclusions.

(1) Vaccines made from a type of *B. welchii* and from strains of *B. Coli* isolated from lambs affected with lamb dysentery have been

TABLE VII.
T.A.M. ALONE, WITH CONTROLS.
A.—*Double Spring.*

Lambs from Inoc. Ewes.	*Lambs died L.D.*	%	*Lambs from Control Ewes*	*Lambs died L.D.*	%
1034	25	2·41	92	5	5·43
900	17	1·88	95	5	5·26
1934	42	2·17	187	10	5·34
B.—*Autumn and Spring.*					
150	0	0	26	6	23·08
226	5	2·25	34	5	14·7
38	0	0	17	0	0·0
52	0	0	28	3	10·7
466	5	1·08	105	14	13·33

used to immunise ewes in Scotland, Northumberland, and Wales, with a view to protecting their lambs against lamb dysentery. Two inoculations (one in autumn and one in spring) were made. The following results were obtained :

(*a*) *Where controls were kept.*—Among 4,046 lambs born from inoculated ewes the mortality was 0·87 per cent., while out of 2,152 lambs from control ewes 8·04 per cent. died.

(*b*) *Where no controls were kept.*—(i.) In Scotland the death rate was 0·77 per cent. among 1,029 lambs. (ii.) In Northumberland it was 4·17 per cent. among 15,560 lambs.

(2) Serum made from types of *B. welchii* was used on young lambs. The following results were obtained :

(*a*) *Where controls were kept.*—Of 1,122 lambs injected five died of lamb dysentery, while of 1,241 untreated 213, or 17·16 per cent., died.

(*b*) *Where no controls were kept.*—Two out of 1,877 injected lambs died.

(3) It would appear that the *B. coli* part of the vaccine plays little or no part in the protection of lambs.

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